

June 12, 1934.

F. C. WAPPLER

1,962,796

HIGH FREQUENCY APPARATUS

Filed Dec. 18, 1931

7 Sheets-Sheet 1

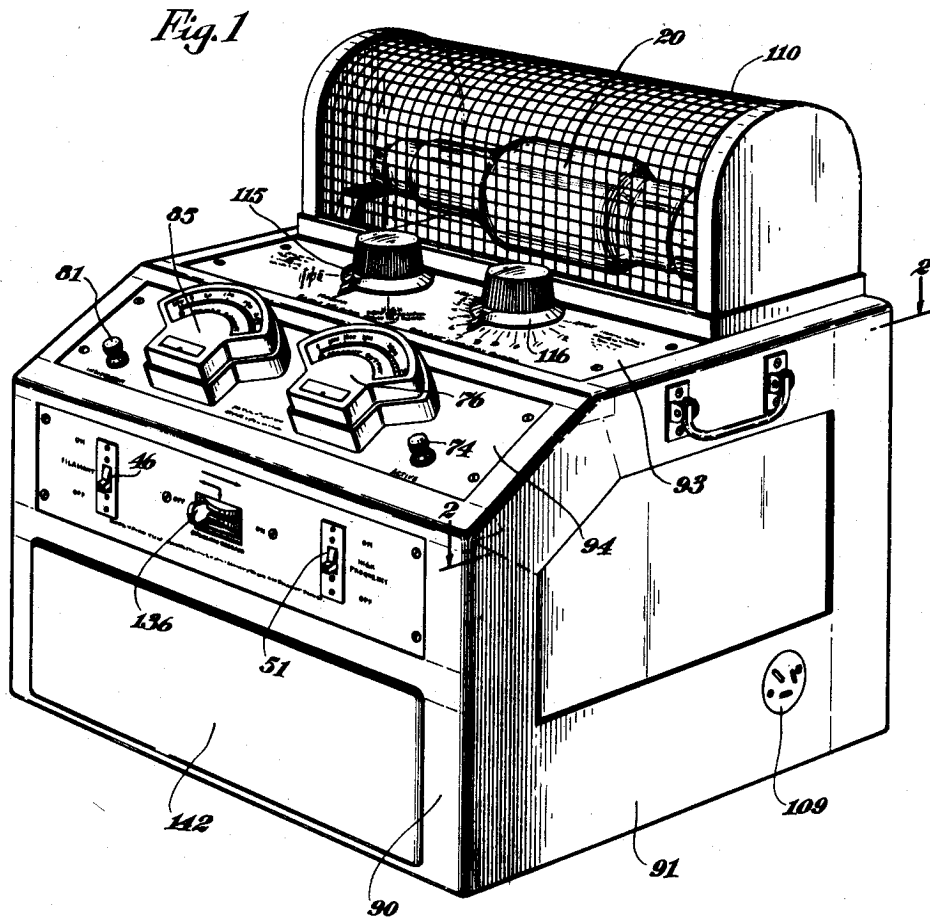
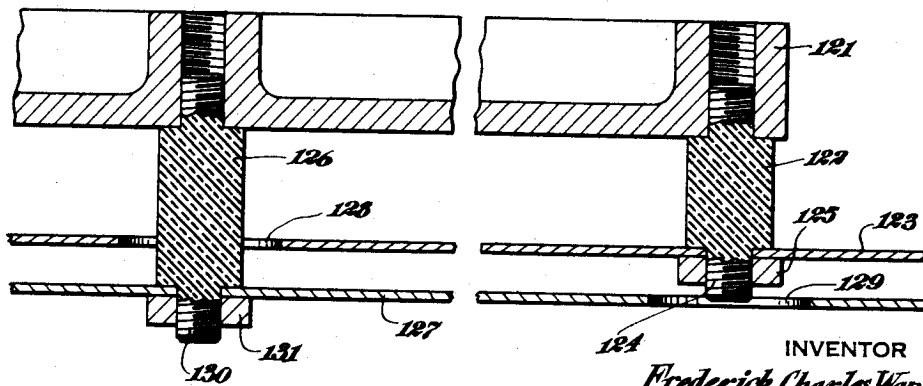


Fig. 8



INVENTOR
Frederick Charles Wappler
BY
Frederick Breitenfeld
ATTORNEY

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F. C. WAPPLER

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7 Sheets-Sheet 2

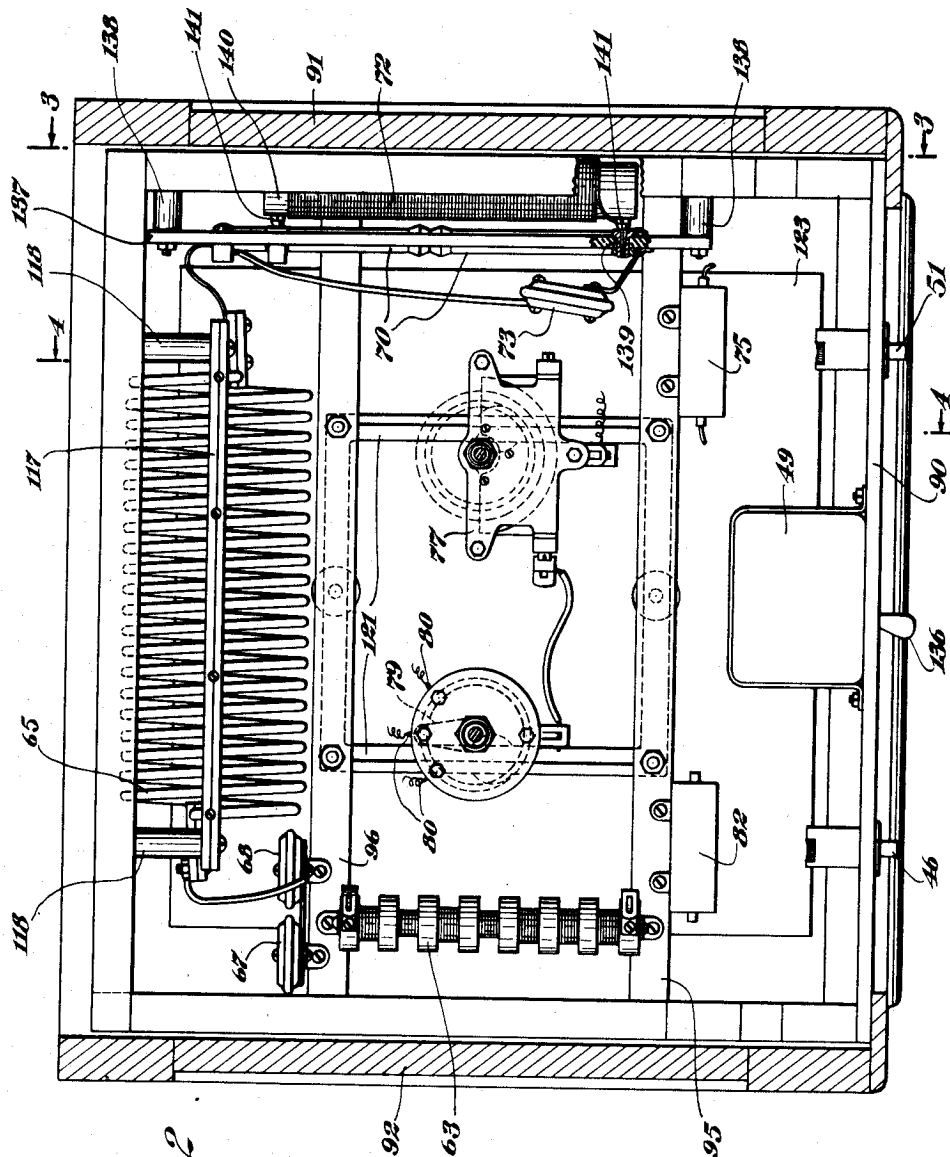


Fig. 2

INVENTOR
Frederick Charles Wappler
BY
Frederick Breitenfeld
ATTORNEY

June 12, 1934.

F. C. WAPPLER

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Fig. 3

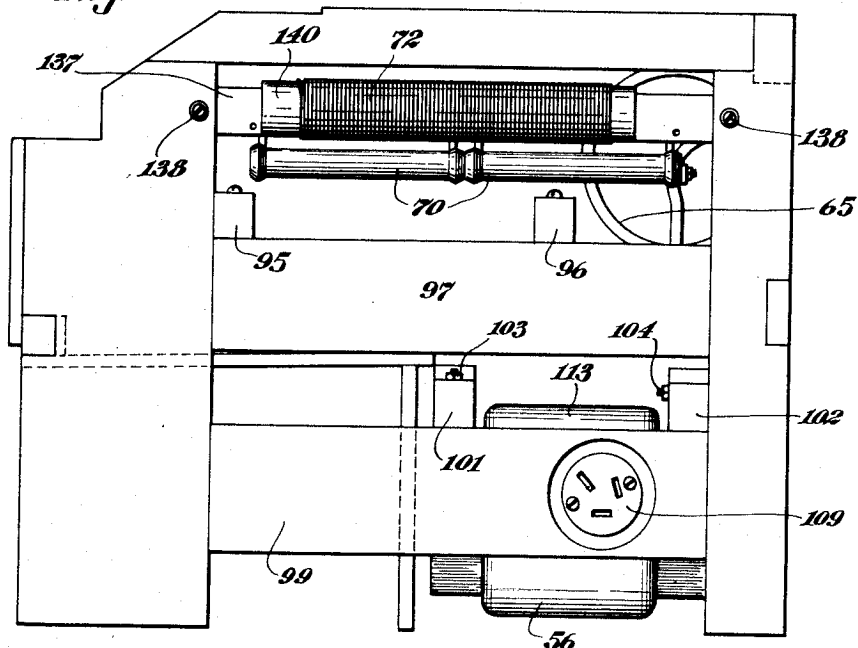
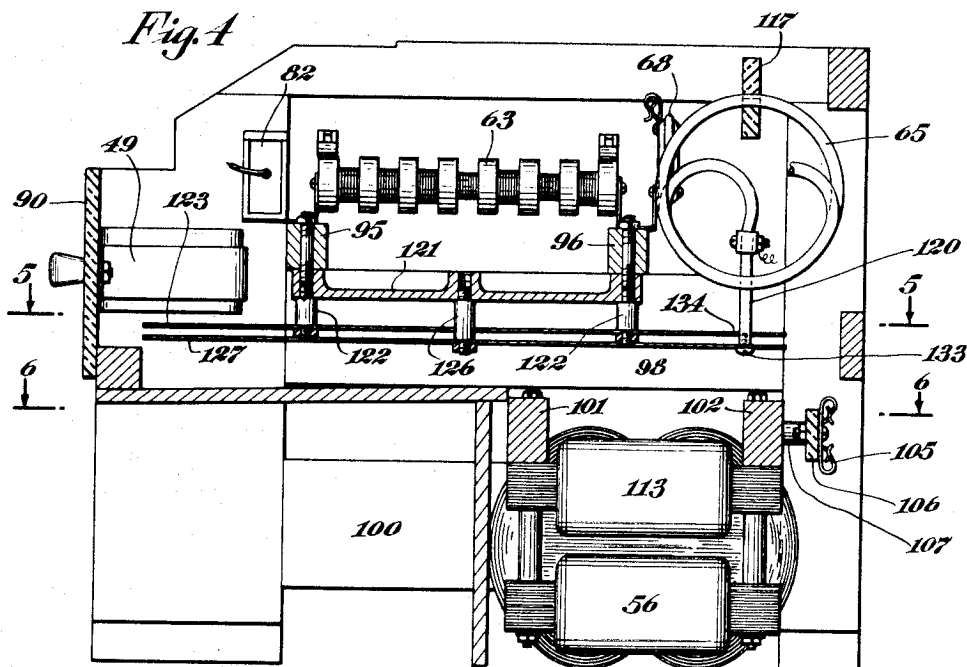


Fig. 4



INVENTOR

Frederick Charles Wappler,

BY

Frederick Gretenfeld

ATTORNEY

June 12, 1934.

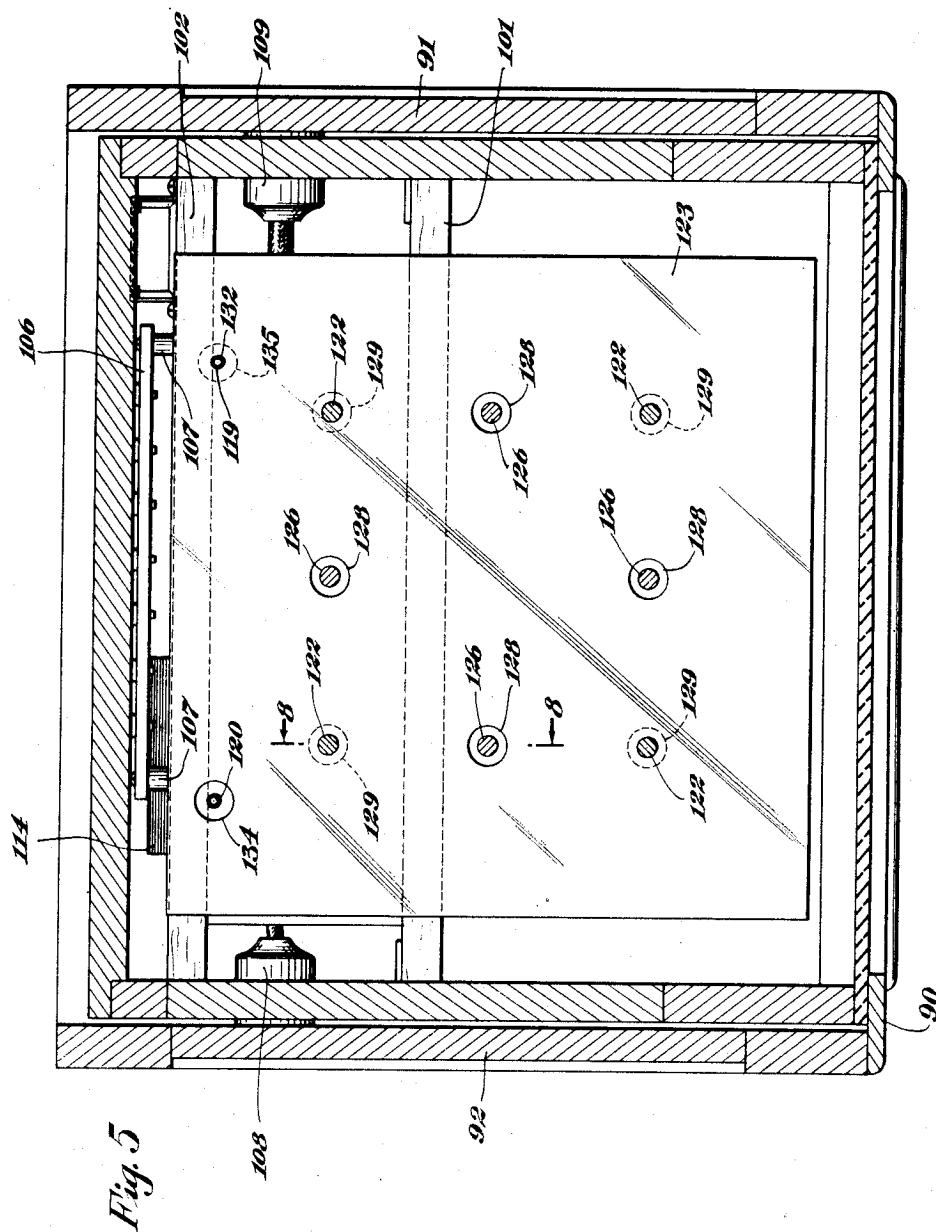
F. C. WAPPLER

1,962,796

HIGH FREQUENCY APPARATUS

Filed Dec. 18, 1931

7 Sheets-Sheet 4



INVENTOR
Frederick Charles Wappler,
BY
Frederick Breenfeldt
ATTORNEY

June 12, 1934.

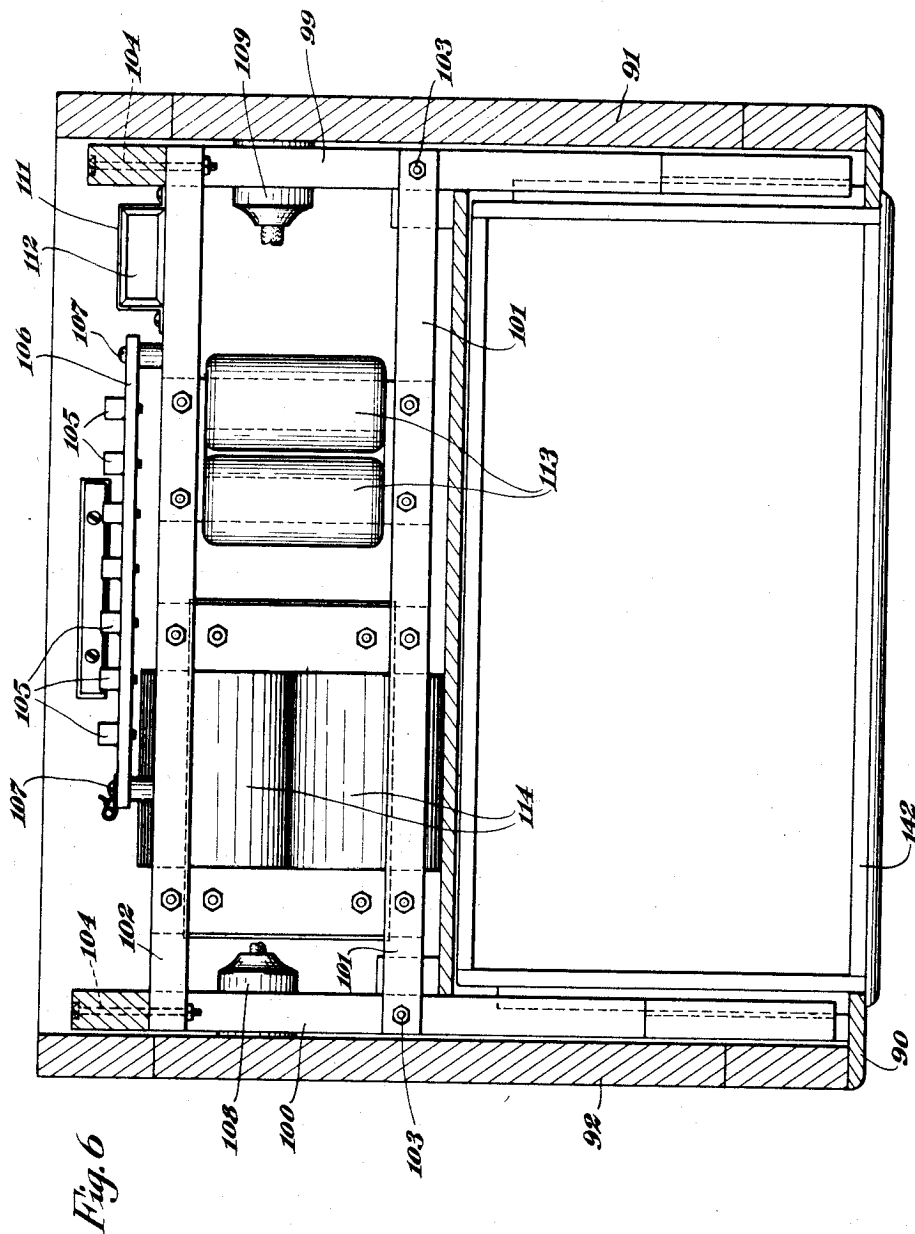
F. C. WAPPLER

1,962,796

HIGH FREQUENCY APPARATUS

Filed Dec. 18, 1931

7 Sheets-Sheet 5



INVENTOR
Frederick Charles Wappler;
BY
Frederick Reitenfeld
ATTORNEY

June 12, 1934.

F. C. WAPPLER

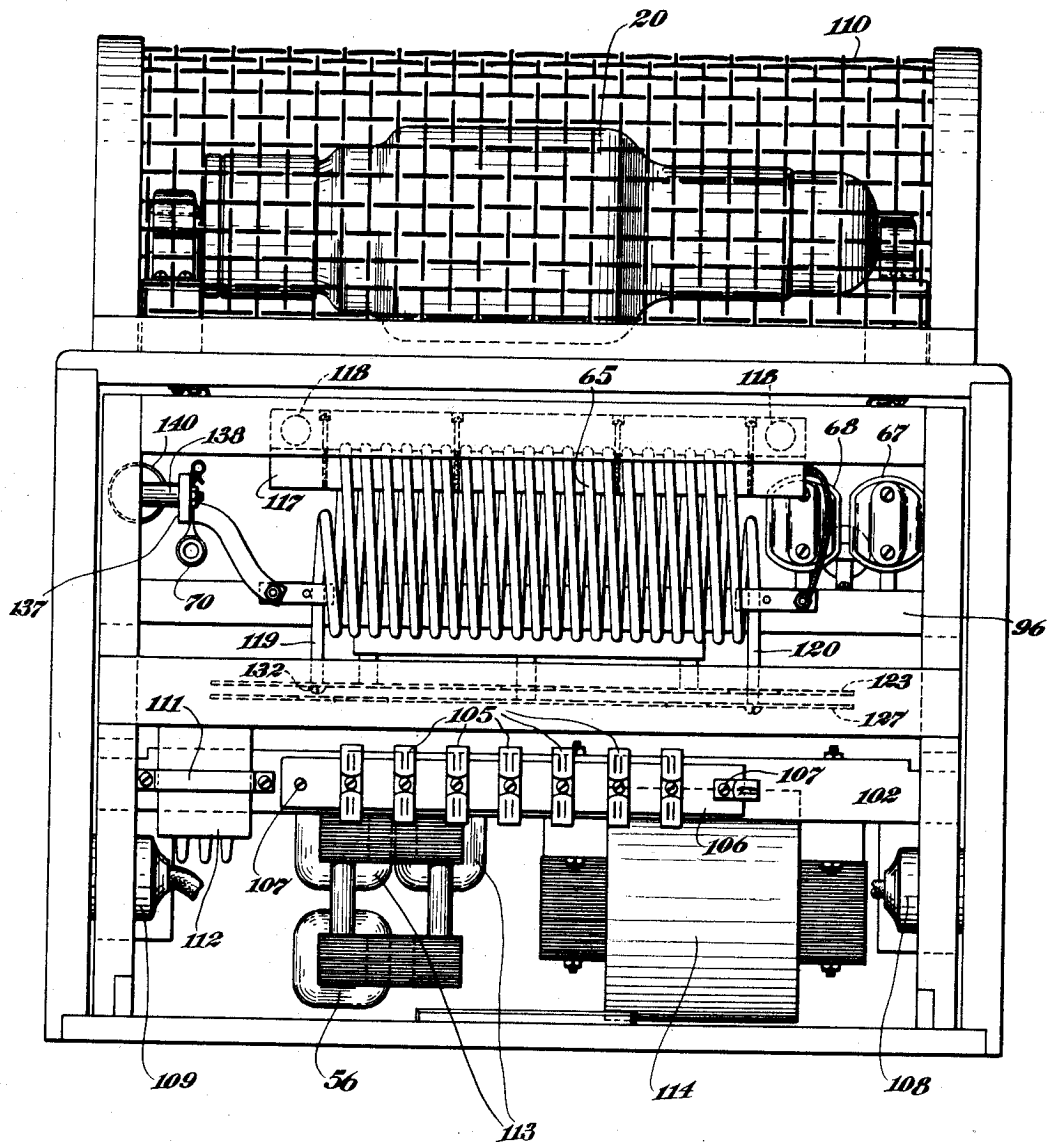
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HIGH FREQUENCY APPARATUS

Filed Dec. 18, 1931

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Fig. 7



INVENTOR
Frederick Charles Wappler
BY
Frederick Reitenfeld
ATTORNEY

UNITED STATES PATENT OFFICE

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HIGH FREQUENCY APPARATUS

Frederick Charles Wappler, New York, N. Y.

Application December 18, 1931, Serial No. 581,908

9 Claims. (Cl. 250—36)

My present invention relates generally to the electromedical and electrosurgical arts, and has particular reference to the generation of high-frequency electric current for therapeutic and analogous purposes.

From one aspect, it is a general object of my invention to provide a new and improved electrical apparatus and circuit for the generation of sustained high-frequency currents.

From a broader aspect, my invention relates to improvements in the electrosurgical and electromedical arts, generally; and an important object of my invention is to provide an apparatus capable of generating high-frequency current which may be used in these arts for all of the purposes recognized today and for entirely new purposes.

It is a more specific object of my invention to provide a compact, relatively inexpensive, and reliable device, in the form of a cabinet or the like, wherein means for generating sustained high-frequency oscillations are arranged in a novel and compact manner within and in association with the cabinet; whereby a unitary piece of apparatus is provided which may be conveniently and economically manufactured, and which may be installed as a single unit in a doctor's office or the like, to be used by him with maximum efficiency, reliability, and safety, and with a minimum amount of manipulation.

Circuits for the generation of high-frequency currents for medical and surgical purposes, among others, are not broadly new. It has always been a problem, however, to provide an arrangement which would operate in a reliable and stable manner under all of the varying loads and conditions that are imposed upon the apparatus during its varied uses. In no case, so far as I am aware, has there ever been devised or constructed a unitary apparatus capable of use for not only surgical purposes but also for non-surgical diathermy.

My present apparatus is characterized by its ability to be employed, at will, for any purpose within the entire range of high-frequency electrosurgical or electromedical treatments recognized today. It complies, in a stable and reliable manner, with any of the widely varying range of requirements called for by the electrosurgical or electromedical arts.

For example, the usual types of apparatus heretofore employed for surgical resection have often proven in practice to be unsatisfactory and inadequate under the stringent yet com-

monly encountered load conditions imposed by resection in a liquid medium; and to my knowledge, it has heretofore been deemed utterly unfeasible and almost inconceivable for such devices to meet the even more difficult conditions of non-surgical diathermy. By the term "non-surgical diathermy" I refer to those utilizations of high-frequency current whereby a non-burning heat is generated in body tissues, as distinguished from a cutting or even a coagulating or cooking effect of the current.

One of the reasons why the usual high-frequency devices, useful to an extent for surgical cutting, have not been suitable for non-surgical diathermy is that a pure heating effect requires much greater power than has heretofore been inherently available in such devices. For such diathermy, spark-gap oscillators have been customarily employed; but a spark-gap device is utterly unsuited for surgical cutting or the like.

In other words, the art has heretofore developed along two distinct lines; and it has been generally recognized and believed that high-frequency electrosurgery (by which I mean to include not only cutting but also coagulation and allied effects) requires one technique and one type of apparatus, while high-frequency non-surgical diathermy requires a quite different type of apparatus.

By my present invention, I provide for a unitary arrangement of apparatus which embodies inherent capabilities of sufficiently broad scope to permit its employment, at will, not only for both extremes of this range of requirements, but for the entire array of conditions in-between. Moreover, my invention has features which permit electrosurgery to be performed in an improved manner and with greater stability, reliability, and ease, and which permit non-surgical diathermy to be practiced in new and highly advantageous ways which constitute marked improvements in this art over the customary spark-gap methods and apparatus.

Thus, with ordinary surgical resection current generators increased loads have heretofore induced such fluctuations in voltage as to cause the apparatus to balk, as a result of which under-water cutting has been notably difficult and satisfactory, and pure heating effects impossible, so far as I am aware. With my present apparatus, there is no balking or voltage fluctuation even under the largest power output requirements.

Similarly, spark-gap generators of current for non-surgical diathermy have been difficult

and even dangerous to use, because of the fact that they necessarily produce damped oscillations, and by virtue of the necessarily high voltages produced at the peaks of the damped oscillations. With my present apparatus, the necessary power, even for non-surgical diathermy, may be withdrawn with ease under uniformly low voltage, as a result of which any likelihood of burning, and of breakdown of insulation, has been reduced to a minimum, if not entirely prevented.

One of the main features of my invention lies in the provision of an oscillating circuit in which smoothly sustained, undamped alternations of high-frequency current are generated by means of a vacuum tube whose output power rating is sufficiently large to permit withdrawal, from the output circuit, of sufficient current to comply, without balking or fluctuation, with even the large requirements of non-surgical diathermy. I am therefore enabled to provide for a withdrawal of whatever current may be necessary, whether large or small, at a uniformly maintained low voltage, and without impairing either the smoothly sustained character of the oscillations or the uniformity of the low voltage.

Certain more specific features of my invention relate to the improvement of the stability and reliability of a high-frequency current generator of this general type. For example, I provide an arrangement whereby a constant yet controllable impedance is always interposed in the output circuit whenever such circuit is subjected to an external load. I also provide means for more accurately and truthfully recording or registering the energy that is withdrawn from the circuit by any particular load that is imposed upon it. I also provide an arrangement for conveniently permitting the operator to control the output energy, more especially to hold the output to a predetermined fraction of the maximum energy that would otherwise be available.

It is a more specific object of my invention to provide an improved mechanical structure, arrangement, and manner of assembly of parts, especially in conjunction with a novel type of cabinet or container, whereby a conveniently small and unified piece of apparatus is provided. For example, it is a feature of my invention to provide an apparatus wherein an oscillating circuit is composed of a coil and a fixed, two-plate, air-gap condenser. While air-gap condensers are, of course, old per se, my present arrangement is of a unique and highly advantageous character in connection with a device of the present type. A further feature lies in the arrangement of elements whereby the assembly and disassembly of the apparatus are greatly facilitated and whereby the adjustment or tuning, during manufacture, is capable of accomplishment in a simplified manner.

I achieve the foregoing objects and advantages, and such other objects and advantages as may hereinafter appear or be pointed out, in the manner illustratively exemplified in the accompanying drawings, wherein—

Figure 1 is a perspective view of a unitary apparatus of the present character;

Figure 2 is a cross-sectional view taken substantially along the line 2—2 of Figure 1;

Figure 3 is a cross-sectional view taken substantially along the line 3—3 of Figure 2;

Figure 4 is a cross-sectional view taken substantially along the line 4—4 of Figure 2;

Figures 5 and 6 are cross-sectional plan views taken substantially along the lines 5—5 and 6—6 of Figure 4;

Figure 7 is a rear view of the apparatus with the rear wall removed to reveal the interior;

Figure 8 is an enlarged, fragmentary, cross-sectional view taken substantially along the line 8—8 of Figure 5; and

Figure 9 is a wiring diagram.

I shall first describe the electrical apparatus per se, as indicated in a general manner in Figure 9, so that the features of structure, assembly, and arrangement hereinafter to be pointed out in greater detail will be more fully understood and appreciated.

Referring to Figure 9, the electrical arrangement comprises, essentially, a vacuum tube adapted to generate high-frequency current, an input circuit adapted to be connected to an ordinary commercial current supply of low frequency such as 60 cycles, an oscillating circuit deriving its energy from the vacuum tube, and an output circuit adapted to draw energy from the oscillating circuit.

The vacuum tube 20 is provided with a plate from which a lead 21 extends, a filament from which the leads 22 and 23 extend, and a grid from which the lead 24 extends.

The filament derives its energy from the secondary coil 25 of a transformer whose primary coil is shown at 26. Thus, the lead 23 is connected at 27 to the lead 28 which extends to one end of the secondary 25; and the filament lead 22 is connected at 29 with the lead 30 which extends to the opposite end of the secondary 25.

For a purpose presently to be set forth in greater detail, a pair of fixed condensers 31 and 32 are arranged in series and are shunted across the secondary 25 by means of the leads 33 and 34. The center point 35 of the secondary 25 is connected by a lead 36 with the point 37 between the condensers 31 and 32. This center tap is also connected to a lead 38 presently to be described.

The condensers 31 and 32 permit the passage of high-frequency currents but serve to block the low-frequency current from the secondary 25. Such low-frequency current is therefore excluded from the lead 33, although high-frequency current may readily pass through this lead and through the condensers 31 and/or 32 to the filament of the tube 20.

The input circuit for the tube 20 comprises the transformer having the primary coil 39 and the secondary coil 40. The primary coil is connected in series by means of the lead 41 with the primary coil 26 of the filament transformer, and the lead 41 is also connected as at 42 with the lead 43 extending from one terminal of the low-frequency power supply 44.

The other terminal of the power supply 44 extends through a lead 45 to a filament switch 46; and at 47 a lead 48 connects directly with the primary 26 of the filament transformer.

From the point 47, a similar connection may be traced to the primary 39 of the plate transformer, viz., through the overload release 49, lead 50, plate switch 51, and lead 52.

The plate switch 51 is designed to be used alternatively with a special switch provided in accordance with my present invention and preferably in the form of a foot switch. This special switch comprises the movable member 53 and the

relatively fixed contact members 54 and 55. When this switch is used, initial manipulation thereof, as by pressing the foot lightly thereon, will bring the contact members 53 and 54 together, and this will close the circuit to the primary 39 through the low-frequency choke coil 56, the circuit being traced from the point 57, through the lead 58, the choke 56, the lead 59, the contacts 53 and 54, and the lead 60, to the point 61, thence through the release 49 and the lead 45, to the power supply 44.

The interposition of this choke in the control circuit for the primary 39 results in reducing the energy which is fed to the plate, so that only a predetermined fraction of the available energy is fed to the output circuit of the device.

When the switch 53 is further manipulated, as by pressing harder thereon, the contact member 53 establishes a connection between the contacts 54 and 55 and thereby short-circuits the choke 56. This permits the full line voltage to be applied to the primary 39.

Obviously, when the normal plate switch 51 is used, the full line voltage is applied.

The secondary coil 40 of the plate transformer connects with the plate through the lead 62 and the high-frequency choke coil 63, whereby high-frequency currents are excluded from the lead 62 and from the input portion of the device.

The oscillating circuit consists of the two-plate, air condenser 64 and the inductance coil 65 arranged in parallel therewith. One side of the oscillating circuit connects through the lead 66 and through the condensers 67 and 68 with the lead 21 and thence with the plate of the tube 20. The condensers 67 and 68 serve to exclude the low-frequency current from the oscillating circuit.

The other side of the oscillating circuit connects with the grid of the tube 20 through the lead 69, the grid-leak resistance 70, lead 71, grid inductance 72, and lead 24. A by-pass condenser 73 is arranged in parallel with the grid lead 70.

The output circuit extends from the active terminal 74 through the protective condenser 75, through the current measuring instrument 76, and through the variable capacitance 77, to the point 78, at which a movable member 79 permits selective connection or tapping to various points 80 along the coil 65.

An indifferent terminal 81 extends through the protective condenser 82 and through the leads 83 and 84 to the grid side of the oscillating circuit, this side being connected by the lead 38 with the neutral center tap 35 of the filament transformer.

In accordance with my invention, a second current measuring instrument 85 (shunted by a condenser 86) is positioned in a lead 87 extending from the neutral point 88 to the secondary coil 40 of the plate transformer.

The electrical operation of the device will be understood, in a general way, by those skilled in the art, from the description given. Certain particular features of my present invention will, however, be pointed out.

(A) The vacuum tube 20 has a power output rating or capability greatly in excess of what would ordinarily be deemed to be necessary. For example, a tube of the order of 250 watts is preferably provided, where the apparatus is designed to generate current having a frequency of the order of 2,000,000 to 5,000,000 cycles per second, and where ordinary 60-cycle, 110-volt

current is employed at the input. The power output capability of such a tube is sufficient to permit a withdrawal, from the output circuit, of sufficient current for at least any recognized purpose, not excluding non-surgical diathermy; and any necessary current, whether small or large, may be withdrawn from the output circuit without impairment of the smoothness or continuity of the sustained oscillations, and without any impairment or fluctuation of the low output voltage.

(B) The selective employment of the switch 53—55 in the input control circuit which includes the low-frequency choke 56 has already been described. By means of this switch, the energy output of the oscillating circuit may be checked to a predetermined fraction of the available energy. As a specific illustration of the value of this arrangement, reference will be made to operations involving resection or cutting by means of a suitable electrode connected to the active terminal 74. In performing such operations, the maximum energy is required for cutting purposes, but in case there is some bleeding, hemostasis may be effected by simply withdrawing pressure upon the foot switch so as to reduce the output energy to about one-half. Under these conditions, the current will be just sufficient to effect a coagulation sufficient to stop bleeding but insufficient to effect a continuance of the desired cutting. Such accurate and immediate control of the output energy is highly desirable under these illustrative circumstances.

(C) The overload release 49 is preferably thermostatic in character and prevents too great a current to be fed to the plate of the tube 20.

(D) The arrangement of the variable capacitance 77 in the output circuit serves in a remarkable manner to stabilize the operation of the device. Whatever the exact reason for this desirable effect may be, I am of the opinion that the variable capacitance 77 serves as a constant yet controllable impedance in the output circuit whenever a load is imposed upon the latter; and that the functioning of the apparatus is thereby controllably stabilized under the widely differing loads that may be imposed upon it.

(E) The arrangement of the two current measuring instruments 76 and 85 in the manner shown is of remarkable advantage in depicting as truthfully as possible the true state of affairs in the output circuit when the device is used for the generation of heat, such as in non-surgical diathermy. The advantage of this arrangement will be more fully appreciated when it is stated that, customarily, only one current measuring instrument has been adapted to be employed, serving to measure current output. This alone, however, does not give a true picture of the energy entering a patient, because with a given current one patient may suffer and complain while another may not. The difficulty heretofore unsolved has its basis in the impossibility of measuring output energy. Such energy may be conveniently measured with low-frequency currents, but with high-frequency currents the phenomena are so different as to make it impossible. In the present instance, the second current measuring instrument 85 serves to obviate this difficulty. It measures the input current to the tube 20, and since this current automatically adjusts itself to the output energy, the instrument 85 serves as a means for measuring a quantity proportional to the output

energy. This alone would, again, be insufficient, but the two instruments 85 and 76 together afford a quite accurate picture of what is actually taking place. The instrument 76 measures

output current, while the instrument 85 measures something which is proportional to output power, which is what is producing the heat.

I will now describe the other features and advantages of my invention, viz., those which relate more particularly to the structural nature of the parts and their novel manner of assembly for producing a commercially feasible and practically useful unitary apparatus. For the sake of convenience, the corresponding mechanical elements will be referred to, wherever possible, by the same reference numerals as are employed in the wiring diagram of Figure 9.

The cabinet of the present unit is shaped, preferably, in substantially the manner shown in Figure 1. It is substantially rectangular, having a bottom wall, a front wall 90, side walls 91 and 92, a rear wall, and a top wall which has the rear horizontal portion 93 and the forwardly inclined portion 94.

Included in the framework are the longitudinally extending beams 95 and 96 supported at their ends upon the transversely extending side stringers 97 and 98 (see Figures 3 and 4). Similarly supported upon the side stringers 99 and 100 are the relatively lower, longitudinal beams 101 and 102. Most of the generating apparatus is supported directly or indirectly from and upon the beams 95 and 96; while the input apparatus, including the transformers and the like, is mounted primarily upon the beams 101 and 102. These latter beams are connected together to form a complete framework by itself, which is bodily removable from the rear lower portion of the apparatus, this being accomplished by releasing the studs or bolts 103 and 104.

This removability, as a unit, of the input circuit apparatus is of great advantage since it permits the transformers and the like to be inspected, repaired, replaced, or adjusted in an extremely simple manner, without necessitating a complete disassembly of the entire apparatus. To permit this removability of the apparatus supported upon the beams 101 and 102, a series of binding posts 105 is mounted in alignment upon an insulating strip 106 supported as at 107 upon the exterior surface of the beam 102. Leads from the power input apparatus are clipped to the binding posts 105, and leads from the permanently positioned electrical apparatus are similarly clipped to these binding posts, so that by simply removing these leads from the binding posts 105 the power input unit is entirely separated electrically from the remainder of the apparatus to permit this unit to be withdrawn in the manner described.

The particular leads which terminate at the binding posts 105 are clearly illustrated in Figure 9, wherein the reference numeral 105 has been applied to those portions of the circuit which represent the binding posts herein referred to. In Figure 9, for example, it is to be noted that the apparatus contained in the upper portion of the diagram is completely removable with the beams 101 and 102, and, more particularly, it is to be noted that this removable unit includes the plate transformer coils, the filament transformer coils, the low-frequency choke 56, and the filament by-pass condensers 31 and 32.

Accessible at the lower rear portion of the side wall 92 is a connector terminal 108 to which connection may conveniently be made to the power source 44. It is this connection which the user simply plugs into a commercial outlet socket or box. Similarly accessible near the lower rear portion of the side wall 91 is a three-pole connector terminal 109 to which connection may conveniently be made to the foot switch 53—55.

Mounted on the exterior of the cabinet, at the rear portion of the top wall 93, is the tube 20 which, in accordance with my present invention, is of a large rating adapted to generate an excess or surplus amount of energy. Preferably, though not necessarily, the tube is enclosed within a cage or the like 110, and the leads from the tube elements are led downwardly into the cabinet through the floor of the cage.

In Figures 6 and 7, the strap 111 supports a box 112 in which the condensers 31—32 are contained. The reference numeral 113 is applied to the two coils of the filament transformer. The manner in which the choke 56 is constructed and supported is indicated. And the reference numeral 114 is applied to the plate transformer whose coils are designated 39 and 40 in Figure 9.

Mounted on the forward portion of the top wall 93 are the manually controllable dial handles 115 and 116, each being mounted upon a spindle which extends downwardly into the cabinet and to the particular piece of apparatus controlled thereby. The handle 115 controls the movable member 79 so as to position it selectively in contact with one or the other of the taps 80.

The handle 116 controls the variable capacitance 77 which may, for example, be in the form of a variable plate condenser.

Mounted in the rear portion of the cabinet, above the removable power input unit, is the coil 65 of the oscillating circuit, and it is preferably composed of rigid copper tubing wound into a helix whose axis is substantially horizontal. The coil is preferably supported by means of an insulating strip 117 supported upon pedestals 118 which project forwardly from the rear wall of the cabinet. The strip 117 may, for example, be provided with openings or slots through which the turns of the coil 65 are caused to pass, as indicated most clearly in Figure 7.

In accordance with one of the main features of my present invention, the terminal ends 119 and 120 of the coil 65 extend downwardly, as shown most clearly in Figures 4 and 7, so as to be connectible, in perpendicular relationship, to the plates of the fixed condenser designated in Figure 9 by reference numeral 64.

The support, construction, and arrangement of this condenser is one of the main features of my present invention and is most clearly illustrated in Figures 4, 5, 7, and 8. A bracket or spider 121 is supported upon the longitudinal beams 95 and 96. It is provided with a series of interiorly threaded bosses, each of which is adapted to receive a stud of insulating material such as bakelite.

There are two sets of these studs. One set, designated in the figures by the reference numeral 122, extends downwardly into engagement with the upper or proximate condenser plate 123. The manner of engagement is shown most clearly in Figure 8. Each of the studs has an attenuated neck 124, exteriorly threaded, this

neck extending through a preformed opening in the plate 123 and being engaged on the underside of this plate by a nut or the like 125.

The other set of studs, designated in the drawings by the reference numeral 126, is similarly constructed, but each stud is slightly longer and is adapted to extend downwardly into a similar mode of engagement with the lower or remote condenser plate 127.

Wherever one of the studs 126 is positioned, the upper condenser plate 123 is provided with an oversized opening 128 to permit the stud to pass freely through the plate 123.

So that both of the condenser plates will have the same area, and also to permit access to the nuts 125, the lower plate 127 is provided with oversized openings 129 in alignment with each of the studs 122.

The construction thus provided is not only staunch and exceptionally firm and simple, but is peculiarly unique and valuable because of the complete elimination of any areas or regions where a breakdown of the insulating material might take place. In other words, it is not sufficient in designing a condenser of the present character merely to support two condenser plates in parallel proximity, because of the extremely high voltages and stresses to which the condenser is subjected. Ordinary spacers between the plates, for example, would be utterly unsuitable because of the extremely short leakage path through these spacers from one plate to the other, a construction which would inevitably result in a complete breakdown of these spacers in an exceptionally short period of time. Such breakdown would frequently manifest itself by a virtual explosion of the spacers and, obviously, the device would be completely unusable until the damage were repaired.

Referring to Figure 8, it will be observed that the features of my present construction obviate any such contingency. The attenuated, exteriorly threaded portion 130 of each stud 126 extends downwardly through the remote plate 127 and is engaged by a nut 131 or the like, this nut lying in its entirety on the remote side of the air gap between the plates 123 and 127. The leakage path between the plates is thus constrained to extend upwardly through one set of studs and then downwardly through the other set, a length which is sufficient to obviate any breakdown. It is to be noted that there is no region where a shorter leakage path exists through insulating material between the two plates. At the same time, the plates are firmly and securely held in proper and predetermined spaced relationship.

The terminal ends 119 and 120 are secured to the condenser plates in a similar manner. The end 119 is secured by means of a stud 132, and the end 120 is supported by means of a stud 133. The upper plate is provided with an oversized opening 134 through which the end 120 extends; and the lower plate is provided with a similar opening 135 to equalize the area of the plates and also to make the stud 132 accessible.

The provision of an air condenser of the present character has a number of advantages. Any breakdown, due to excessive stresses, occurs in the air gap, and the heat is thus immediately dissipated, the parts remaining intact and unimpaired. There is a tremendous saving in space, especially where the condenser is arranged parallel to one of the walls of the cabinet

and especially the floor of the cabinet, as in the present construction. And the plates of the condenser serve at the same time as an efficient shield between the coils of the transformers beneath it and the coils, especially the main coil 65, above it.

The arrangement of parts hereinbefore described and clearly illustrated in the drawings permits of the convenient accommodation in a compact and non-interfering manner of the other elements of the apparatus. The current measuring instruments 85 and 76 are conveniently mounted upon the sloping portion of the top wall 94. The active terminal 74 is also mounted on this wall portion, adjacent to one end thereof, and the indifferent terminal 81 is arranged near the other end of this wall.

On the front wall, at the upper portion thereof, are arranged the filament switch 46, the control handle 136 of the overload release, and the plate switch 51.

On the inside of the front wall, behind the control handle 136, is the overload release mechanism 49.

In Figure 2, I have shown the manner in which the longitudinal beam 95 conveniently supports the protective condensers 75 and 82. Also, supported transversely across the beams 95 and 96 is the high-frequency choke 63. And supported upon the beam 96 are the condensers 67 and 68.

One of the features of my invention lies in mounting the grid inductance 72 in a conveniently accessible, removable manner. Referring to Figures 2 and 3, and also to Figure 7, an insulating panel or strip 137 is supported adjacent to the side wall 91, preferably upon pedestals 138. Supported from this strip is the grid leak resistance 70, in parallel with which the by-pass condenser 73 is arranged. Projecting outwardly from the outer surface of the strip 137 is a pair of sockets 139 electrically connected, respectively, with one end of the resistance 70 and with the grid of the tube 20. The grid inductance 72 is composed of a coil or wire wound upon a tube 140 or the like, and projecting from this tube are plugs 141 connected to the opposite ends of the coil 72, respectively, and adapted to engage removably within the sockets 139.

As a result of this arrangement, all of the elements of the device may be conveniently assembled from the bottom up, and the entire assembly may be completed with the exception of the application of the outer panel or covering of the side wall 91. The device may then be tested and adjusted, and any tuning to be accomplished may be done in an extremely simple and expeditious manner by simply withdrawing the tube 140 bodily from the assembly, increasing or decreasing the turns thereon, and then replacing it. The tuning may thus be of an extremely accurate character, and when finally adjusted to the satisfaction of the manufacturer there is nothing left but to apply the outer covering of the wall 91.

One of the incidental advantages of my present construction, especially the arrangement whereby the power input apparatus is in the rear lower portion of the cabinet while the other apparatus is arranged in the upper portion of the cabinet above the horizontally arranged air-gap condenser, lies in the fact that the forward lower portion of the cabinet may be conveniently used for storage purposes. Thus, I

have illustratively shown a drawer 142 slidably accommodated in the lower front portion of the cabinet. In this drawer, accessories, electrodes, and similar pieces of apparatus may be conveniently accommodated.

It will thus be seen that my present invention provides, in a single unitary construction, an apparatus which can be used for at least every recognized therapeutic or surgical application of high-frequency current to the human body. As hereinbefore stated, my apparatus is usable, at will, for electrosurgery, as well as for non-surgical diathermy. This includes electric cutting, as in prostatic resection; coagulation or cooking, either massive or superficial; desiccation or dehydration, with a minimum of coagulation, as in the treatment of skin blemishes or growths; non-surgical diathermy, generally, either for heating small areas or large areas, and including both single and double-pole diathermy; auto-condensation, as in the treatment of high blood pressure; fever generation; removal of pedunculated growths; and the like. The apparatus is also suitable for use in the therapeutic treatment which involves the passage of current through a fluid electrode; also for the purpose of maintaining a continuous arc in a fluid, whatever the particular purpose or object may be.

The capabilities of my present invention are by no means restricted to the procedures hereinbefore illustratively specified; and experiments and demonstrations have proved, and are continuing to prove, that the inherent capabilities and possible utilizations of the current generated by the present apparatus are still not fully appreciated or realized. For example, the current is of such a character, probably by virtue of its low voltage characteristic, that even the thinnest sheaths of insulation remain utterly unaffected. The importance of this advantage will be readily appreciated when it is borne in mind that electrodes and similar instruments, heretofore generally employed for high-frequency resection or the like, have been necessarily provided with relatively thick and cumbersome insulations, usually including a relatively bulky sleeve of quartz or the like, closely adjacent to the exposed operative electrode wire or head. Heretofore, even such relatively heavy insulations have failed and broken down all too frequently; yet with my present apparatus and circuit arrangement, I have been enabled to employ electrodes consisting of wires or the like ensheathed in nothing more than very thin layers of ordinary insulation, which would ordinarily have exploded or broken down almost instantaneously if used with ordinary types of surgical resection apparatus. As a result, the advent of my present apparatus has permitted, and will continue to permit, the complete redesigning of electrodes, endoscopes, and similar diagnostic and operative instruments, whereby operations and procedures heretofore believed to be utterly unfeasible and cumbersome are becoming more and more possible and practical.

Similarly, in the application of electrodes to the body for non-surgical diathermic purposes, it has been necessary heretofore to apply the electrodes in a wet and soaped contacting relationship. Shifting of electrodes has all too frequently resulted in burns and similar injuries; and even during removal of such electrodes, burns have resulted as the area in contact with the body diminishes during the removal. With

my present apparatus, I have found it possible to apply electrodes for non-surgical diathermic purposes in an entirely dry state. There is no sparking or burning even where such electrodes are applied, dry, to hairy portions of the body, for example, the chest. I have also found it possible to apply such electrodes to the exterior of the clothes of a patient, a procedure which would have heretofore entailed sparking, burning, and injury to both clothes and patient. Furthermore, I have found it possible to utilize electrodes which are completely ensheathed in insulation, such as rubber or the like. The use of a completely insulated and ensheathed electrode for purely non-surgical diathermy would heretofore have been considered impossible, and certainly utterly unfeasible, so far as I am aware.

I venture to say that my present invention presages not only an entire redesign of diathermic electrodes and the like, but also the development of an entirely new technique in the practical adaptation of high-frequency currents to non-surgical diathermy and to electrotherapy in general.

In the process of coagulating or cooking, the present current appears to have a far greater penetrative effect, and accomplishes thorough coagulation without any surface carbonization, an advantage which will be readily appreciated by those skilled in the art, since carbonization almost always results in secondary hemorrhages and prevents proper healing and rehabilitation of the tissues involved.

Obviously, changes in the details herein described and illustrated for the purpose of explaining the nature of my invention may be made by those skilled in the art without departing from the spirit and scope of the invention as expressed in the appended claims. It is therefore intended that these details be interpreted as illustrative, and not in a limiting sense.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent is—

1. In a high-frequency apparatus of the character described, a cabinet, an oscillating circuit in said cabinet and comprising an inductance coil and a fixed, two-plate, air condenser, said condenser being arranged to lie substantially parallel to one of the walls of said cabinet, power-input apparatus on one side of said condenser, and said coil being arranged in its entirety on the opposite side of said condenser so that the latter acts as a shield between said power-input apparatus and said coil.

2. In a high-frequency apparatus of the character described, a cabinet, an oscillating circuit in said cabinet and comprising an inductance coil and a fixed, two-plate, air condenser, said condenser being arranged to lie substantially parallel to the floor of said cabinet, power-input apparatus beneath said condenser, and said coil being arranged in its entirety above said condenser so that the latter acts as a shield between said power-input apparatus and said coil.

3. In a high-frequency apparatus of the character described, a substantially rectangular cabinet, an oscillating circuit in said cabinet and comprising an inductance coil and a fixed, two-plate, air condenser, said condenser being arranged to lie substantially parallel to the floor of said cabinet and spaced from said floor, said coil being arranged in its entirety above

said condenser, and power-input apparatus beneath said condenser and at the rear of said cabinet, whereby said condenser serves as a shield between said coil and power-input apparatus, and whereby the space beneath said condenser and in front of said power-input apparatus is available for storage purposes.

4. In a high-frequency apparatus of the character described, a cabinet, an oscillating circuit in said cabinet and comprising an inductance coil and a fixed, two-plate, air condenser, a supporting bracket on one side of said condenser, and two sets of insulating posts extending from said bracket to said condenser, one set of posts being secured to the proximate condenser plate, the other set being secured to the remote condenser plate.

5. In a high-frequency apparatus of the character described, a cabinet, an oscillating circuit in said cabinet and comprising an inductance coil and a fixed, two-plate, air condenser, a supporting bracket on one side of said condenser, and two sets of insulating posts extending from said bracket to said condenser, one set of posts being secured to the proximate condenser plate, the other set being secured to the remote condenser plate, the condenser plate nearest said bracket being provided with a series of oversized openings adapted to permit passage therethrough of the posts extending to said remote condenser plate.

6. In a high-frequency apparatus of the character described, a cabinet, an oscillating circuit in said cabinet and comprising an inductance coil and a fixed, two-plate, air condenser, a supporting bracket on one side of said condenser, and two sets of insulating posts extending from said bracket to said condenser, one set of posts being secured to the proximate condenser plate, the other set being secured to the remote condenser plate, the condenser plate nearest said bracket being provided with a series of oversized openings adapted to permit passage therethrough of the posts extending to said remote condenser plate, and the latter being provided with openings aligned with the posts extending to said proximate condenser plate.

7. In a high-frequency apparatus of the character described, a cabinet, an oscillating circuit in said cabinet and comprising an inductance coil and a fixed, two-plate, air condenser, a supporting bracket on one side of said condenser, and two sets of insulating posts extending from said bracket to said condenser, one set of posts being secured to the proximate condenser plate, the other set being secured to the remote condenser plate, each of the latter posts having an attenuated, exteriorly threaded end adapted to extend through said remote condenser plate.

8. In a high-frequency apparatus of the character described, a cabinet, an oscillating circuit in said cabinet and comprising an inductance coil and a fixed, two-plate, air condenser, a supporting bracket on one side of said condenser, and two sets of insulating posts extending from said bracket to said condenser, one set of posts being secured to the proximate condenser plate, the other set being secured to the remote condenser plate, and means for fastening said last-mentioned posts to said remote condenser plate, said means being disposed in its entirety on the remote side of the air gap between said plates.

9. In a high-frequency apparatus of the character described, an oscillating circuit comprising an inductance coil and a fixed, two-plate, air condenser, a supporting bracket on one side of said condenser, two sets of insulating posts extending from said bracket to said condenser, one set of posts being secured to the proximate condenser plate, the other set being secured to the remote condenser plate, each of the posts having attenuated, exteriorly threaded ends adapted to extend, respectively, through the condenser plates being supported thereby, said coil comprising a rigid, conductive tubing arranged alongside of the condenser in a helix whose axis is parallel to the plane of the condenser, one terminal end of said tubing being directly connected to the adjacent condenser plate, the other terminal end of said tubing extending through said condenser plate and being directly connected to the remote condenser plate.

FREDERICK CHARLES WAPPLER.